13.0 DETAILED ANALYSIS OF ALTERNATIVES

The five alternatives that remain following screening in Section 12.0 are analyzed in detail in this section to present relevant information needed to select a site remedy. As outlined in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a), nine criteria are used as the basis for the detailed analysis of these five alternatives. These criteria address a more detailed analysis of effectiveness, implementability, and cost than the evaluation completed during development and screening of alternatives in Section 12.0.

After detailed analysis, alternatives are compared to evaluate relative performance in relation to each specific criterion. This comparison will be used by the EPA as the basis for selecting a preferred alternative as an appropriate remedy for the Muscoy Plume OU.

This section is divided into two major subsections: evaluation of alternatives and comparative analysis of alternatives. Before presenting the subsections, design concentration of contaminants in groundwater and design flow rate used in the detailed analysis are briefly described below.

TCE, PCE and cis-1,2-DCE concentrations used for development of treatment alternatives were based on groundwater quality data obtained from municipal wells in the Muscoy Plume OU. The latest round of groundwater data obtained in April-May 1993 sampling event is detailed in Section 5.0. Concentrations of 10 $\mu g/\ell$, 30 $\mu g/\ell$, and 10 $\mu g/\ell$ for TCE, PCE and cis-1,2-DCE, respectively, are the design concentrations used to develop alternatives. The design concentrations are based on the maximum concentration of these contaminants (6 $\mu g/\ell$, 27 $\mu g/\ell$, and 6 $\mu g/\ell$ for TCE, PCE, and cis-1,2-DCE, respectively). Other detected VOCs were only evaluated for their possible secondary effects on the groundwater treatment technologies.

As presented in Section 12.1, the proposed four extraction areas pumping rate ranged between 5,000 and 7,000 gpm. For the purpose of the detail analysis, a design flow rate of 7,000 gpm was used. This flow rate allows for additional system capacity and provides for greater design flexibility. Based on the design flow rate, it was assumed that each of the four extraction wells would pump equally (i.e., 1,750 gpm).

13.1 EVALUATION OF ALTERNATIVES

This section describes the detailed evaluation of the five remaining alternatives using nine criteria. Each alternative is evaluated against all of the identified criteria except those for state and community acceptance. These final two criteria will be addressed after comments are received on the Proposed Plan.

The nine criteria identified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA 1988a) are:

- Overall Protection of Human Health and the Environment
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume

- Short-term Effectiveness
- Implementability
- Cost
- State Acceptance
- Community Acceptance

The nine criteria used for this analysis evaluate detailed aspects of effectiveness, implementability and cost which were evaluated during screening of both technologies and alternatives. The first two criteria (overall protection of human health and the environment, and compliance with ARARs) must be met by any alternative to be eligible for selection. The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility or volume; short-term effectiveness; implementability; and cost) are considered to be the trade-off criteria during selection. The final two criteria (state and community acceptance) will be evaluated after the preferred alternative is identified, the Proposed Plan is developed and comments are received from concerned agencies and the public. Each of the nine criteria are discussed below:

Overall Protection of Human Health and the Environment: Protectiveness is the primary requirement that CERCLA remedial actions must meet. A remedy is protective if it adequately eliminates, reduces, or controls all current and potential risks posed from each exposure pathway identified at the site through the use of treatment, engineering, or institutional controls. The preliminary risk assessment in Subsection 8.2 shows that treatment of VOCs in the groundwater to MCLs meets this requirement.

Compliance with ARARs: The ARARs compliance criterion evaluates a remedial alternative's ability to attain the specific requirements pertinent to the alternative. Subsection 8.1 summarizes the pertinent ARARs.

Long-term Effectiveness and Permanence: This criterion assesses the potential risk remaining at the site after the response actions have been completed. The focus is on the extent and effectiveness of the controls that may be required to manage risk, therefore, two elements are considered: magnitude of residual risk and adequacy and reliability of controls.

The magnitude of residual risk measures the risk remaining from untreated waste or treatment residuals following completion of the response action.

The adequacy and reliability of controls addresses the adequacy, suitability, and long-term reliability of any controls that are necessary to manage treatment residuals or untreated wastes that remain on site. These elements are measured: to ensure that any exposure to human and environmental receptors is within protective levels; assess the potential need to replace technical components of the alternative; and outline the risks involved if the remedial action needs replacement.

Reduction of Toxicity, Mobility, or Volume: This criterion assesses the permanence and degree that an alternative reduces the toxicity, mobility or volume of contaminants. Aspects of this criterion may consist of the amount of treated material, expected levels of contaminant reduction, reversibility of the treatment, and the amount of treatment residuals.

This criterion is satisfied when treatment reduces the contamination through destruction, or irreversibly reduces the contaminant toxicity, mobility, or volume.

Short-term Effectiveness: This criterion assesses the alternative's effect on human health and the environment during the construction and implementation phase until the RA objectives are achieved. This includes short-term impacts on the neighboring community, workers, and the environment.

Implementability: Implementability measures the technical feasibility, administrative feasibility and the availability of services and materials, to construct, operate, and maintain the remedial alternative.

Technical feasibility refers to the technical unknowns during construction and operation; the reliability of an alternative during implementation; the ease of implementing necessary additional RAs; and the ability to effectively monitor the alternative.

Administrative feasibility refers to the required actions to coordinate with other offices and agencies to obtain approvals and permits.

Availability of services and materials refers to the availability of treatment, storage and disposal services; the availability of necessary equipment, materials and specialists; and the availability of possible technologies.

Cost: Costs were divided into four categories: Groundwater Extraction, Treatment Facilities, End Use, and Groundwater Monitoring Wells. The capital and O&M costs are determined for each major component within each category. Capital costs are major expenditures for equipment, labor, and materials required to construct and start up the facilities. O&M costs are those costs required to operate the facilities after construction is complete. O&M costs include operating labor, maintenance labor and materials, utility consumption, project and treatment facility analytical services, an equipment replacement contingency, and miscellaneous other costs. The basis for the costs developed for alternatives is presented in Table 13-1.

Capital costs for major components such as the GAC units or stripping towers, advanced oxidation system tanks, chlorination system, pH system or pumps were obtained from suppliers of the equipment. A percentage of construction costs was utilized to estimate the cost of elements such as site electrical work, generally proportional to the size and complexity of the project. When costs were obtained as percentage of construction, or when several quotations were obtained for the same component, engineering experience was applied to assure the costs conform to recent costs for similar facilities and that the costs presented were representative of the planned facilities. The following percentages are used to estimate the total capital cost: 15% of capital cost for contractor overhead and profit (Contractor OH&P), 15% of capital cost for engineering design and management activities, and 5% for activities related to project administration. Finally, a 20% contingency was applied to the Capital Cost estimate to cover changes in the project scope and design refinements not covered in the suppliers' quotations or the initial plant design.

Table 13-1

COST BASIS

Cost Factors[(1)]	Discount Rate = 5 percent per annum Number of Years = 30
Operational Factors	Operational Hours = 24 hrs/day Operational Days = 365 days/yr
Unit Cost Factors[(2)]	Electricity = \$0.10/kWh Labor = \$45/hour kWh/lb Ozone = 11
Material/Chemical Costs[(2)]	GAC (liquid phase)[3] = \$1.00/lb GAC (vapor phase)[3] = \$2.00/lb Hydrogen Peroxide = \$0.65/lb Chlorine = \$0.20/lb UV Lamp = \$60/lamp (lamp life = 1.2 yrs.)
Cost Not Included in Estimates	Land Procurement Power Transmission Line Construction Municipal System Improvements All Samples Analyzed at No Cost Using EPA CLP

Note:
(1) Cost factors are based on EPA guidance (USEPA 1988a)
(2) Unit cost factors and material/chemical costs are based on vendor information.
(3) Costs are for new (or virgin) carbon.

13.2.7 Cost

This section compares the costs, then presents cost sensitivity analysis for the alternatives.

Cost Comparison

A feasibility cost comparison criterion is based on the total present worth of each alternative. Present worth analysis provides a method of evaluating and comparing costs that occur over a time period by discounting all future expenditures to the present year. The total present worth of each alternative is calculated using capital cost, annual O&M cost, duration (or lifetime) of the project, and a discount rate. Detail of present worth calculations is presented in Section 13.1.

Table 13-13 summarizes capital cost, annual O&M cost, and total present worth for all alternatives. Figure 13-6 shows the comparison of capital and annual O&M costs for the alternatives. Similarly, Figure 13-7 shows the comparison of total present worth of the alternatives.

Alternative 2 and Alternative 5 are identical except the end use: the Alternative 2 uses municipal end use whereas reinjection end use is used in the Alternative 5. Because of this difference, capital cost for the Alternative 5 is larger than that for the Alternative 2.

The capital cost of Alternative 1 is the least as it includes construction of four monitoring wells. The capital costs of Alternatives 2 and 3 are within comparable range. Among the alternatives that include treatment systems, the capital cost of Alternative 3 is the lowest, and the capital cost of Alternative 5 is the highest.

The total present worth of the alternatives in Table 13-13 shows that Alternative 1 is the least expensive because of its small capital and annual O&M costs. Alternative 4 is the most expensive because of its higher capital cost and annual O&M cost. The Total Present Worth cost for Alternative 5 (approximately $30.8 million) is approximately $4.8 million higher than Alternative 2 (approximately $26.0 million), and the Total Project cost for Alternative 2 is approximately $4.5 million higher than Alternative 3.

Based on the estimated total present worth, Alternative 1 is given the highest ranking score of 5 (because its cost is the last), and Alternative 4 is given the lowest ranking score of 1 (its cost is the highest). The ranking score of the other alternatives are based on their comparison of the estimated total present worth.

Sensitivity Analysis

Cost sensitivity analysis for the alternatives is presented in this subsection. The sensitivity analysis assesses the effect of varying key assumptions or factors associated with the cost estimate. Assumptions or factors that can significantly affect the present worth of the alternatives are considered for the sensitivity analysis. The sensitivity of cost associated with alternatives can be evaluated by varying those key factors and calculating the corresponding variation on the estimated cost.

Table 13-13

COMPARISON OF COST FOR THE ALTERNATIVES

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Capital Cost ($)	1,153,200	8,066,572	7,014,511	12,473,067	13,962,772
Annual O&M Cost ($)	68,800	1,168,410	943,130	1,270,290	1,096,740
Total Present Worth ($)	2,210,825	26,027,898	21,512,731	32,000,538	30,822,354

Table 13-15

SENSITIVITY ANALYSIS: VARIATION OF AIR/WATER RATIO - ALTERNATIVE 3

Air/Water Ratio		Capital Cost	Annual O&M	Present Worth	Total Present Worth
Low	20	$7,005,211	$938,070	$14,420,435	$21,425,646
Design	25	$7,014,511	$943,130	$14,498,220	$21,512,731
High	30	$7,023,811	$953,280	$14,654,250	$21,678,061

Notes: Present Worth column shows the present worth of annual O&M cost calculated for a duration of 30 years with a discount rate of 5%.

Total Present Worth column is obtained by adding Capital Cost column and Present Worth column.

Table 13-16

SENSITIVITY ANALYSIS: VARIATION OF DOSAGE RATE - ALTERNATIVE 4

Ozone Peroxide (O_3) (H_2O_2)		Capital Cost	Annual O&M	Present Worth	Total Present Worth
Low	7:3	$11,874,612	$1,117,870	$17,184,402	$29,059,014
Design	10.5:4.5	$12,473,067	$1,270,290	$19,527,471	$32,000,538
High	14:6	$13,077,722	$1,484,960	$22,827,475	$35,905,197

Notes: Present Worth column shows the present worth of annual O&M cost calculated for a duration of 30 years with a discount rate of 5%.

Total Present Worth column is obtained by adding Capital Cost column and Present Worth column.

Table 13-17

SENSITIVITY ANALYSIS: VARIATION OF ANNUAL CARBON USAGE - ALTERNATIVE 5

Annual Carbon Usage (x 1000 lb)		Capital Cost	Annual O&M	Present Worth	Total Present Worth
Low	365	$13,962,772	$908,040	$13,958,800	$27,921,572
Design	550	$13,962,772	$1,096,740	$16,859,582	$30,822,354
High	730	$13,962,772	$1,280,340	$19,681,964	$33,644,736

Notes: Present Worth column shows the present worth of annual O&M cost calculated for a duration of 30 years with a discount rate of 5%.

Total Present Worth column is obtained by adding Capital Cost column and Present Worth column.

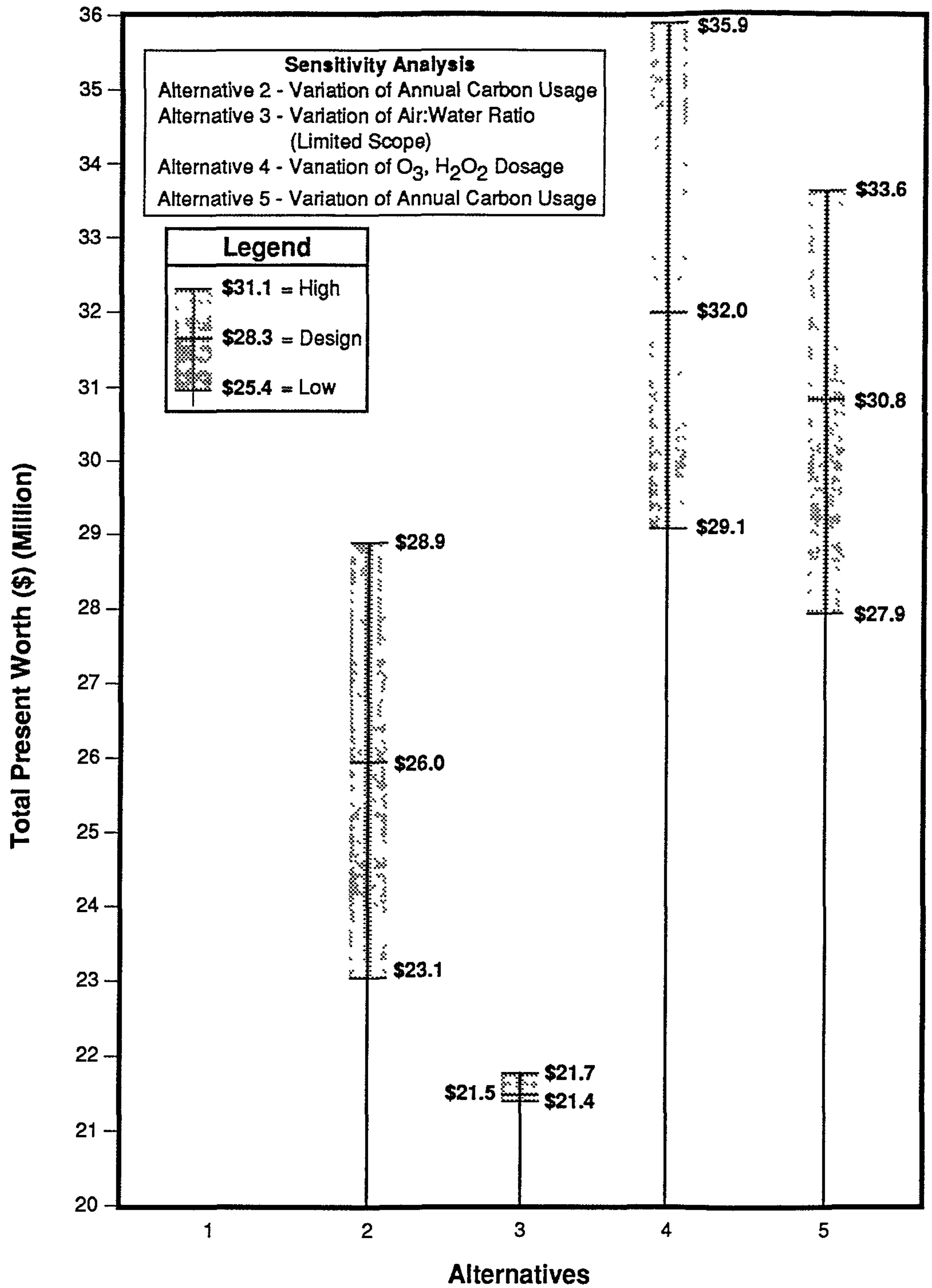

Figure 13-8
Sensitivity Analysis of Alternatives
Muscoy Plume OU RI/FS Report
Newmark Groundwater Contamination Superfund Site

14.0 REFERENCES

Best, B. 1992. Personal communication via telephone. USDA Soil Conservation Service, Redlands, California. July 21.

California Air Resources Board (CARB). August 1990. Proposed Identification of Trichloroethylene as a Toxic Air Contaminant - Technical Support Document Part A.

———. August 1991. Proposed Identification of Perchloroethylene as a Toxic Air Contaminant - Technical Support Document Part A.

California Regional Water Quality Control Board (RWQCB). May 1991. Soil Gas Survey: Muscoy Area (Former Camp Ono Facility). California Regional Water Quality Control Board - Santa Ana Region. Riverside, California.

Danskin, W.A., and J.R. Freckleton. 1989. Ground-Water Flow Modeling and optimization Techniques Applied to High Ground-Water Problems in San Bernardino, California. U.S. Geological Survey.

Domenico, P.A. and F.W. Schwartz. 1990. Physical and Chemical Hydrogeology.

Dragun, J. 1988. The Soil Chemistry of Hazardous Materials. The Hazardous Materials Control Research Institute. Silver Spring, Maryland. 458 p.

Dutcher, L.C., and A.A. Garrett. May 1963. Geologic and Hydrologic Features of the San Bernardino Area, California, with Special Reference to Underflow Across the San Jacinto Fault. USGS Water Supply Paper 1419.

Ecology and Environment, Inc. September 1989. North San Bernardino Preliminary Assessment/Site Investigation (PA/SI).

———. October 1991. CERCLA Screening Site Inspection: Camp Ono.

Envicom Corp. June 1989. City of San Bernardino General Plan.

Environmental Monitoring Systems Laboratory, Office of Research and Development (EMSL). September 1990. Aerial Photographic Analysis of the Newmark and Camp Ono Sites, San Bernardino, California. TS-PIC-90774. Las Vegas, Nevada.

FEMA. 1994. Federal Emergency Management Agency. Flood Insurance Maps for City of San Bernardino.

Fife, D.L., D.A. Rodgers, G.W. Chase, R.H. Chapman, and E.C. Sprotte. 1976. Geologic Hazards in Southwestern San Bernardino County, California. Special Report 113. California Division of Mines and Geology, p. 40.

Freedman, D.L., and J.M. Gossett. 1989. Biological reductive dechlorination of tetrachloroethylene and trichloroethylene under methanogenic conditions. Applied Environmental Microbiology, v. 55, pp. 2144-2151.

Freeze, A.R. and J.A. Cherry. 1979. Groundwater. p. 604.

Golden Software, Inc. 1993. SURFER Vers. 4.16.

Hardt, W.F., and J.R. Freckleton. 1987. Aquifer Response to Recharge and Pumping San Bernardino Ground-Water Basin, California. USGC Water-resources Investigations report 86-4140, p. 69.

Hardt, W.F., and C.B. Hutchinson. September 1980. Development and Use of a Mathematical Model of the San Bernardino Valley Ground-Water Basin, California. USGC Open-File report 80-576, p 80.

Hassett, J.J.; W.L. Banwart and R.A. Griffin. 1983. Correlation of Compound Properties with Sorption Characteristics of Nonpolar Compounds by Soils and Sediments: Concepts and Limitations. Chapter 15 in Environmental and Solid Wastes: Characterization, Treatment, and Disposal. pp. 161-178.

Henry, S.M., and D. Grbic-Galic. 1991. Influence of endogenous and exogenous electron donors and trichloroethylene oxidation toxicity on trichloroethylene oxidation by methanotrophic cultures from a groundwater aquifer. Applied Environmental Microbiology, 57:1770-1776.

Howard, Philip H. (ed.). 1990. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Vol. II - Solvents.

Karickhoff. S.W. 1981. Semi-Imperial Estimation of Sorption of Hydrophobic Pollutants on Natural Sediments and Soils. Chemosphere Vol. 10 No. 8, pp. 833-46.

Keller, J.J. and Associates. 1992. Chemical Regulatory Crossreference.

Lyman, W.J., W.E. Reehl, and D.H. Rosenblatt. 1990. Handbook of Chemical Property Estimation Methods. American Chemical Society, Washington, DC.

MacKay, D.M. and P.V. Roberts and J.A. Cherry. 1985. Environmental Science Technology. 19(5), 384-92.

MacKay, D.M. and T.M. Vogel. 1985. Groundwater Contamination by Organic Chemicals: Uncertainties in Assessment Impact. Second Canadian/American Conference on Hydrology. pp. 50-59.

McCarty, P.L. 1988. Bioengineering issues related to in situ remediation of contaminated soils and groundwater. In: Environmental Biotechnology, ed. G.S. Omenn.

The cost factors set forth in Table 13-1 form the basis for determining the O&M costs presented in the cost estimate for each alternative. Electrical utility costs were estimated based on typical energy requirements for each major component, such as pumps or motors. Material costs were based on the usage estimates presented in the design criteria table for each alternative and the unit cost factors presented in (Table 13-1). Unit cost factors were obtained from vendors and were based on 1994 quotations. The labor associated with each O&M cost component was either obtained from the vendors or based on engineering experience with similar facilities. Based on the above, a total annual operating cost was estimated for each alternative. The present worth of the O&M component for each alternative over the 30-year period was determined using a 5% discount rate before taxes and after inflation in accordance with EPA Guidance (EPA 1988a).The total present worth is the sum of the 30-year present worth O&M and the total capital cost.

After the present worth of each alternative was determined, individual costs were evaluated through a sensitivity analysis. The cost impact of variations in major cost elements for which there were uncertainties associated was assessed. The elements considered in the sensitivity analysis are detailed in the discussion of cost for each alternative in Subsection 13.2.7.

State Acceptance: This criterion reflects the statutory requirement to provide for state involvement. State comments may be addressed during the development of the FS, although formal state comments usually will not be received until the state reviews the draft RI/FS and the draft Proposed Plan prior to the public comment period.

Community Acceptance: This criterion refers to community comment on the remedial alternatives under consideration, where community is broadly defined to include all interested parties.

Table 13-2 summarizes general response actions and estimated costs for all alternatives evaluated in this section. Detailed analyses of the alternatives are given below.

13.1.1 Alternative 1: No Action (Monitoring)

The No Action alternative includes quarterly sampling and water level monitoring of 3 existing monitoring wells (Cajon Landfill), four new (to be installed) monitoring wells, and 15 existing municipal supply wells. Because this alternative does not provide a permanent remedy, it is subject to the 1986 CERCLA amendments which, in part, require that contamination remaining on site be reviewed no less than every five years.

Under this alternative, four new monitoring wells would be constructed in the vicinity of the leading edge of the plume. The purpose of the new monitoring wells is to monitor plume migration downgradient toward the municipal supply wells. Each of the wells would have a total depth of 1,200 feet. These wells would be developed and then sampled quarterly along with the existing monitoring and municipal wells.

Overall Protection of Human Health and the Environment - This remedial alternative does not reduce risks to human health or the environment because contaminants are not eliminated, reduced or controlled by monitoring alone. Additional short-term and long-term threats may result from continued migration of the contaminant plume.

Table 13-2

SUMMARY OF DETAILED EVALUATION OF ALTERNATIVES
Muscoy Plume OU

General Response Action	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Groundwater Extraction	▪ None	▪ Extract 7000 gpm groundwater from 4 wells at plume front	▪ Same as Alternative 2	▪ Same as Alternative 2	▪ Same as Alternative 2
Treatment	▪ None	▪ Treat VOCs with aqueous-phase GAC	▪ Treat VOCs with air stripping with BACT off-gas treatment	▪ Advanced oxidation (Ozone/Peroxide)	▪ Same as Alternative 2
End Use	▪ Monitor groundwater quality	▪ Convey treated effluent to City Distribution System	▪ Same as Alternative 2	▪ Same as Alternative 2	▪ Inject treated 7000 gpm water using 8 injection wells
CRITERIA			EVALUATION		
Overall Protection of Human Health and the Environment	▪ Does not reduce risks to human health or the environment. Usually implemented with other alternatives	▪ Adequately eliminates contaminants through treatment	▪ Same as Alternative 2	▪ Same as Alternative 2	▪ Same as Alternative 2
Compliance with ARARs	▪ Does not satisfy ARARs	▪ Meets ARARs.	▪ Same as Alternative 2	▪ Bench and pilot studies required to determine if ARARs are able to be met	▪ Same as Alternative 2
Long-term Effectiveness and Permanence	▪ Does not provide long-term effectiveness	▪ Residual risk is low ▪ Adequate and reliable system	▪ Same as Alternative 2	▪ Residual risk is low ▪ Treatability studies required to determine the adequacy and reliability of the system	▪ Same as Alternative 2
Reduction of Toxicity, Mobility, or Volume	▪ No reduction of toxicity, mobility, or volume	▪ Irreversibly reduces contaminant toxicity, mobility and volume	▪ Same as Alternative 2	▪ Same as Alternative 2	▪ Same as Alternative 2

Table 13-2 (Cont'd.)

SUMMARY OF DETAILED EVALUATION OF ALTERNATIVES
Muscoy Plume OU

General Response Action	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
CRITERIA (Cont'd.)	**EVALUATION (Cont'd.)**				
Short-term Effectiveness	▪ Provides short-term effectiveness	▪ High degree of short-term effectiveness	▪ Same as Alternative 2	▪ Provides satisfactory short-term effectiveness	▪ Same as Alternative 2
Implementability	▪ Easy to implement ▪ Reliable and effective for monitoring contamination	▪ Technically and administratively implementable	▪ Standard to construct, reliably operate, and maintain ▪ Treatment units require regular monitoring of control systems	▪ Innovative remedial approach that is undemonstrated for expected flow rates ▪ May require full-scale convention treatment system as a contingency measure. ▪ Requires personnel training to operate systems	▪ Same as Alternative 2
Capital Cost(1) Annual O&M Cost(1) Total Present Worth(1)	\$1.2 million \$0.7 million \$2.2 million	\$8.1 million \$1.2 million \$26.0 million	\$7.0 million \$0.9 million \$21.5 million	\$12.5 million \$1.3 million \$32.0 million	\$14.0 million \$1.1 million \$30.8 million

Note: The final two criteria (state and community acceptance) will be addressed after comments are received on this RI/FS report.
(1) The cost (capital, O&M, and total present worth) represents estimated cost based on design criteria, vendor information, experience with similar type of projects and engineering judgment.

This alternative is usually implemented in conjunction with other alternatives involved with active remediation to enhance protective measures.

Compliance with ARARs - The No Action alternative does not remove nor contain contaminated groundwater. Because potential for human exposure to contamination is not eliminated, it does not provide protection for human health by reducing contaminant levels to MCLs, and therefore does not satisfy ARARs.

Long-Term Effectiveness and Permanence - The No Action alternative does not provide long-term effectiveness and permanence.

This alternative has a high magnitude of residual risk due to potential long-term risks to human health and the environment resulting from contaminant migration in groundwater.

Although this alternative is effective and reliable in monitoring contaminant migration within the Muscoy Plume OU, it has a low measure of adequacy and reliability of control because it allows continued contaminant migration in groundwater.

Reduction of Toxicity, Mobility, or Volume - This alternative does not reduce the toxicity, mobility, nor volume of contaminants because there is no containment, removal, treatment, nor disposal of contaminated groundwater.

Short-Term Effectiveness - The No Action alternative does provide short-term effectiveness.

There are no construction or implementation phases associated with this alternative that would be a risk to human health and the environment. Workers responsible for sample collection and site inspections would require proper personal protection equipment.

In terms of the time until RA objectives are met, this alternative will not accomplish meeting RA objectives.

Implementability - This alternative is reliable and effective in monitoring contamination and is easy to implement technically, but is administratively poor.

Administratively, long-term management would be associated with this alternative since contamination remains unchanged. Quarterly sampling requires some administrative and regulatory attention. Necessary services, equipment, and personnel are available.

Cost - Table 13-3 presents the costs associated with Alternative 1. The total present worth cost of this alternative is approximately $2.2 million (capital cost - approximately $1.2 million, annual O&M cost - approximately $0.7 million).

Table 13-3

ESTIMATED COST - ALTERNATIVE 1: NO ACTION

Description	Quantity	Unit	Material	Total Cost Labor	Total	Material	Total Cost Labor	Total
CAPITAL COST								
Groundwater Monitoring Wells								
Wells	4800	lf	$50	$105	$155	$240,000	$504,000	$744,000
Subtotal								$744,000
TOTAL CONSTRUCTION COST								$744,000
Contractor OH & P		15%						111,600
Engineering & Const. Management		15%						111,600
Administration		5%						37,200
Contingency		20%						148,800
TOTAL CAPITAL COST								$1,153,200
ANNUAL O&M COST								
Groundwater Monitoring								
Monitoring Wells	4	Quarter	$8,400	$8,800	$17,200	$33,600	$35,200	$68,800
Subtotal								$68,800
TOTAL ANNUAL O&M COST								$68,800
PRESENT WORTH OF ANNUAL O&M COST								$1,057,625
TOTAL PRESENT WORTH								$2,210,825

13.1.2 Alternative 2: Aqueous-Phase GAC with Municipal End Use

This alternative uses groundwater extraction wells placed at the leading edge of the plume. The extracted groundwater would be transmitted through underground piping to an aqueous-phase GAC treatment plant. The treated groundwater would be discharged into the municipal water supply system. Design criteria for this alternative are presented in Table 13-4.

Groundwater Extraction

Four extraction wells, with a capacity of approximately 1,750 gpm each, spaced at approximately 1,700 feet apart, would be constructed in the location shown in Figure 13-1. The exact location of the wells will be determined during the RD phase. The wells would be drilled to an approximate depth of 1,000 feet and would withdraw water from the two water producing aquifers in this area. Line shaft vertical turbine pumps would be installed in each well. Where possible the motors and equipment would be installed above ground. The water collection system would consist of 16-inch and 24-inch diameter pipe buried in the local streets. The 24-inch diameter, buried, transmission pipeline would convey the collected raw water from the extraction well area to the proposed treatment plant located at the corner of Base Line Street and Pennsylvania Avenue. The proposed pipeline route and the locations of treatment plant and extraction wells are shown on Figure 13-1.

This general location has not been chosen for a treatment plant, but is in a location adjacent to both the approximate location of the extraction system and a large water transmission pipeline (the Baseline Feeder). This location is being used for cost estimation purposes only. If EPA, DTSC, and the City of San Bernardino Municipal Water Department can reach a mutually acceptable agreement, it may be feasible to utilize the existing 19th Street treatment facility (1820 19th Street, west of Flores Street). Despite the additional pipeline needed to bring water to the treatment plant and back to the Baseline Feeder following treatment, there will be significant cost savings by using the 19th Street treatment facility. The cost analysis is presented later in this section.

Treatment System

The layout of the proposed treatment plant is shown on Figure 13-2. The proposed site of the groundwater treatment facility is not located within the 100-year flood hazard area of Lytle Creek Wash or any other creek or channel (FEMA 1994). The proposed facility will be situated on an existing paved or compacted site and no alterations in drainage patterns or surface runoff are anticipated. Existing surface flows will continue within current alignments and no alteration in the course or flow of runoff is anticipated. The proposed facility is also not located within a wetland or riparian area.

For cost estimation purposes, the design effluent VOC concentrations were set at one-half the drinking water standards (Table 13-4).

Table 13-4

DESIGN CRITERIA
ALTERNATIVE 2

Item	Units	Quantity
GROUNDWATER EXTRACTION SYSTEM		
1. Extraction Wells		
Number	each	4
Capacity (each)	gpm	1,750
Total Capacity	gpm	7,000
Estimated Well Depth	ft	1,000
Approximate Depth to Groundwater	ft	150
Casing Diameter	inch	20
Approximate Pumping Head (each)	ft	200
Extraction Pump Rating (each)	hp	90
2. Raw Water Transmission System		
24-inch Diameter	lf	2,680
18-inch Diameter	lf	3,800
16-inch Diameter	lf.	3,600
TREATMENT SYSTEM		
1. Plant Capacity	gpm	7,000
	MGD	10.1
Influent Concentration		
Tetrachloroethylene (PCE)	$\mu g/\ell$	30
Trichloroethylene (TCE)	$\mu g/\ell$	10
cis-1,2-Dichloroethene (cis-1,2-DCE)	$\mu g/\ell$	10
Effluent Concentration		
Tetrachloroethylene (PCE)	$\mu g/\ell$	2.5
Trichloroethylene (TCE)	$\mu g/\ell$	2.5
cis-1,2-Dichloroethene (cis-1,2-DCE)	$\mu g/\ell$	3.0

Table 13-4 (Cont'd.)

DESIGN CRITERIA
ALTERNATIVE 2

Item		Units	Quantity
2.	Treatment		
	Type: Granular Activated Carbon		
	Number of Units (pairs)	each	10
	Unit Operation	--	series
	Plant Operation	--	parallel
	Flow Per Unit	gpm	700
	Total Number of Vessels	each	20
	Empty Bed Contact Time (EBCT) (each vessel)	min	7.5
	EBCT (per pair)	min	15
	Carbon Volume (each)	ft^3	715
	Carbon Volume (each pair)	ft^3	1.430
	Carbon Weight (per vessel)	lb	20,000
	Carbon Weight (per pair)	lb	40,000
	Total Plant Carbon	lb	400,000
	Estimated Carbon Life (per vessel)	days	133
	Estimated Annual Usage	lb	550,000
3.	Effluent Tank		
	Working Capacity	gal (1000)	175
	Size (Diameter x Height)	ft	44 x 16
	Seismic Construction	--	anchored
4.	Disinfection		
	Type: Gaseous Chlorine		
	Dosage Rate	mg/L	0.5 - 1.0
		lb/day	42 - 84
	Residual	mg/L	0.3 - 0.5
	Unit Size	lb/day	200
	Control	--	continuous
	Storage Cylinder Size	lb	2,000
	Number of Cylinders	each	4
	Feed Pump	each	1
	Feed Pump Rating	hp	1

Table 13-4 (Cont'd.)

DESIGN CRITERIA
ALTERNATIVE 2

Item	Units	Quantity
5. Backwash System		
Rate	gpm	1,000
Nominal Time	min	20
Tank Size (Diameter x Height)	ft	26 x 8
Tank Working Capacity	gal (1000)	28
Tank Seismic Construction	--	anchored
Number of Backwash Pumps	each	1
Backwash Pump Rating	hp	15
6. Start Up Filtration		
Type: Bag Filters		
Number of Units	each	2
Number of Bags (per unit)	each	46
Flow per Unit	gpm	3,500
Flow per Bag	gpm	150
END USE		
1. Municipal System		
Pumps: Vertical		
Number	each	4
Total Pumping Rate	gpm	7,000
Pumping Rate (each)	gpm	1,750
Approximate Pumping Head (each)	ft	175
Pump Rating (each)	hp	80

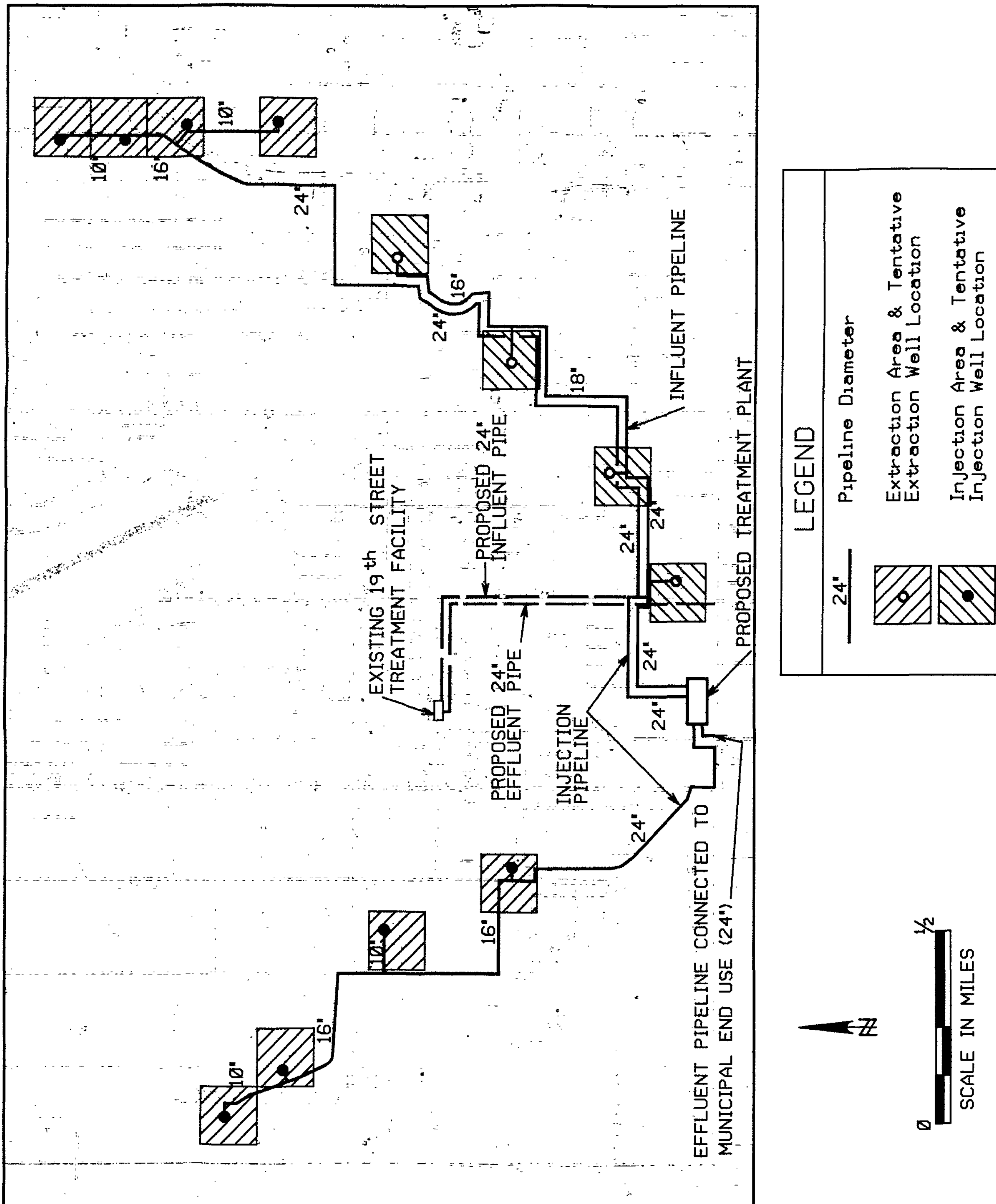

FIGURE 13-1

TREATMENT PLANT, EXTRACTION & INJECTION WELL LOCATION & PIPELINE ROUTE

URS Consultants, Inc. Sacramento, Ca	MUSCOY PLUME OU RI/FS REPORT NEWMARK GROUNDWATER CONTAMINATION SUPERFUND SITE

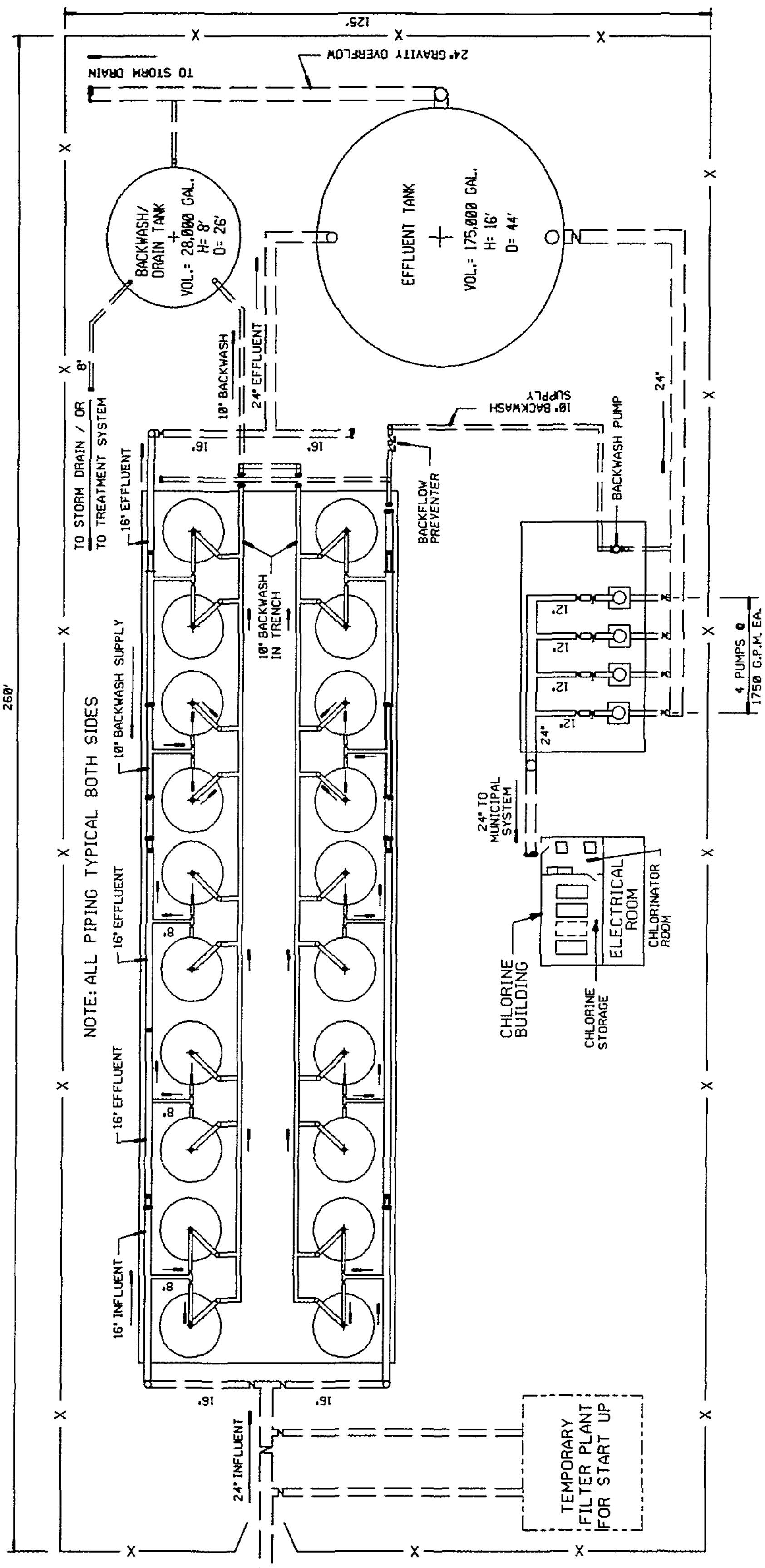

FIGURE 13-2

ALTERNATIVE 2
AQUEOUS GAC WITH MUNICIPAL END USE

URS Consultants, Inc. Sacramento, Ca	MUSCOY PLUME OU RI/FS REPORT NEWMARK GROUNDWATER CONTAMINATION SUPERFUND SITE	

The treatment process consists of pairs of GAC vessels operating in parallel to treat the total plant flow. Table 13-4 provides the specific plant design data. The operation would be similar for each pair of vessels. Raw water enters the first (lead or primary) vessel from a common header where initial contaminant removal takes place, then flows to the second (lag or secondary) vessel where final contaminant removal (to meet discharge requirements) is accomplished. Water samples would be routinely taken from piping following the lead tank. When sample results indicate that the effluent contaminant level from the lead vessel reaches approximately 90% of the raw water contamination level, carbon in the lead vessel would be replaced. While the lead vessel's effluent contamination is increasing, the lag vessel would be removing the remainder of the contaminant load. After replacement of the spent carbon in the lead vessel the flow sequence would be reversed with the partially used second vessel functioning as the new lead vessel. The vessel pairs come complete with all valving and piping required to direct the flow into the series operation mode and change the lead and lag vessel configuration. Other GAC configurations could be used successfully. The final system design will be during the remedial design phase.

Effluent System. Finished water would be discharged from the lag vessel to a common header which conveys the water to an effluent tank. The effluent tank would act as a balancing clearwell and forebay for the booster pumps and would be equipped with level sensors to control the operation of the effluent pumps. The effluent tank would also provide clean water storage to backwash the carbon vessels.

Disinfection. The water processed by the treatment system is not expected to require disinfection. However, a chlorination system is planned to provide a chlorine residual in the water discharged to the municipal system. The system would consist of chlorine regulators, tank scales, automatic switch over units, and continuous chlorine residual analyzers to assure a constant residual. Chlorine would be delivered to, and stored in, standard 1-ton cylinders. The chlorination system would be housed in its own building with separate storage and chlorination rooms. Leak detection, reduced pressure principle room ventilators, and scrubber units would be provided for safety in case a chlorine leak occurs.

Backwash System. Besides the ability to control influent and effluent piping operations, the system is also capable via piping and valving to direct clean backwash to each of the carbon units and wash water to a common disposal header. Finished water is piped to the bottom of each vessel and flows upward through the carbon, thus backwashing the carbon bed. The wash water then flows to a backwash holding tank where it is discharged at a constant rate to the storm drain or to the treatment system. The backwash tank is capable of accommodating the high volume, high flow rate surge required to clean the units. A rinse cycle, that re-seats the carbon and removes fine materials would also be applied before the units are placed back on line. The backwash cycle would be initiated manually when a pressure buildup, indicating plugging of the carbon beds by suspended solids, is observed in any vessel.

Start-Up Filtration. At the well development and plant start-up stage there would be an increased solids loading on the plant. During this time, temporary pre-filtration would be provided at the head of the plant. The filters would consist of disposable bag-type filters. Once the wells are producing water with a low suspended solids concentration the pre-filtration plant would be removed.

End Use

This alternative would supply a treated, disinfected water suitable for use by the local municipality. The plant pump station would consist of four booster pumps sized to pump 7,000 gpm with all pumps operating in parallel.

Groundwater Monitoring Wells

Four new monitoring wells would be installed in the vicinity of the proposed extraction areas. The four monitoring wells are only an estimate for costing purposes. The actual monitoring program will be designed during the RD phase. The purpose of the new monitoring wells is to evaluate the effectiveness of the extraction system. The wells would be drilled to a total depth of 1,200 feet.

Overall Protection of Human Health and the Environment - Aqueous-phase GAC treatment with municipal end use would protect human health and the environment. All state and federal drinking water standards (MCLs) for the COCs will be achieved in the treated water. The extraction system is expected to prevent COCs greater than MCLs from reaching other drinking water wells downgradient.

This alternative is a treatment control which transfers contaminants from groundwater to activated carbon by adsorption in aqueous carbon treatment vessels. Off-site carbon regeneration or incineration serves to contain and destroy contaminants adsorbed during remediation. On-site regeneration and other disposal options (landfilling) may be available but were not evaluated.

Compliance with ARARs - Alternative 2 does comply with the ARARs identified in the ARARs analysis (Subsection 8.1), including treatment of contaminated water to MCLs. Although off-site activities are not evaluated as ARARs, all applicable requirements for off-site actions would be observed.

Long-Term Effectiveness and Permanence - The aqueous-phase GAC with municipal end-use alternative would provide long-term effectiveness and permanence.

The magnitude of residual risk after remediation would be low because groundwater contaminants are extracted and removed from the site. The only residuals remaining after treatment would be VOCs that combined with organic carbon in the soil. This alternative is adequate and suitable to treat the volume of groundwater expected to be encountered within Muscoy Plume OU. It is also a proven and reliable technology for treating groundwater and does not result in untreated wastes remaining on site.

There is limited exposure to human and environmental receptors that are within protective levels, mainly during spent carbon handling. The potential need to replace the alternative or the components of the alternative is low because of its proven capability.

Reduction of Toxicity, Mobility, or Volume - This alternative would permanently and irreversibly reduce contaminant toxicity, mobility, and volume through carbon adsorption and regeneration. It would reduce levels of contamination to meet RA objectives.

This alternative would meet the CERCLA/SARA preference for prior treatment before off-site disposal of hazardous waste by treating spent carbon before disposal. It is likely that spent carbon would be incinerated, thereby destroying contaminants, before disposal of residual ash. Upon completion of the remedial action, the only subsurface residual contamination remaining would be that adsorbed to organic carbon combined in the soil at the site.

Short-Term Effectiveness - The aqueous-phase GAC with municipal end-use alternative would provide a high degree of short-term effectiveness.

During the construction and implementation phases of this alternative, significant health threats to area residents or the environment are not expected. Personnel responsible for handling spent carbon would need to be properly protected (via personal protective equipment) against dermal contact and inhalation of carbon dust. Risk of exposure during carbon exchange is low because spent carbon is transferred in hoses as a slurry.

Implementability - The aqueous-phase GAC with municipal end-use alternative would be implementable, both technically and administratively.

The aqueous-phase GAC technology is demonstrated and commercially available. During construction and operation, significant technical unknowns are not expected, other than standard details associated with large process construction projects.

This alternative is reliable to operate and maintain during implementation, and additional RA is not expected to be difficult to implement. Monitoring of the alternative is considered to be easily accomplished at the extraction well, GAC unit, and regeneration facility.

Administratively, permits for on-site treatment, off-site spent carbon transport, and approval for treated water disposal into the municipal supply are required and would be expected to be appropriately obtained.

Availability of regeneration facilities, necessary equipment, and personnel is expected to be high.

Cost - Table 13-5 presents the costs associated with this alternative. The estimated costs for this alternative are: capital cost - approximately $8.1 million, annual O&M cost - approximately $1.2 million, and total present worth - approximately $26.0 million.

The City of San Bernardino's 19th Street treatment facility is located near the corner of 19th and Flores Streets. The facility consists of eight 20,000 lb GAC vessels, and the vessels can be operated in parallel or in series. With series operation, the flow rate is 700 gpm with a total flow of 2,800 gpm, and the flow of 1,400 gpm can be used in parallel operation with a total flow rate of 5,600 gpm. The vessels are 11.5 feet in diameter with a pressure rating of 75 psig at 150°F. The vessels are skid mounted and set on a concrete pad. The facility is provided with a chlorination system and effluent tank with a capacity of 258,000 gallons. If the 19th Street facility (8 GAC vessels, chlorination system, and effluent tank) is modified to include the proposed GAC system (the design criteria, Table 13-6), then for Alternative 2, the capital cost is estimated to be approximately $7.5 million. This cost includes the cost for additional influent and effluent pipeline required to bring water to/from the 19th Street treatment facility. If the 19th Street facility is not used for modification, the capital cost of Alternative 2 is approximately $8.1 million. Thus, approximately $0.6 million (or 7%) can be saved in the equipment capital cost if the 19th Street treatment facility can be used for the RA. There is no change in the annual O&M when the 19th Street treatment facility is used for modification.

Table 13-5

ESTIMATED COST - ALTERNATIVE 2: AQUEOUS-PHASE GAC WITH MUNICIPAL END USE

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST								
Groundwater Extraction								
Extraction Wells	4,000	lf	$70	$180	$250	$280,000	$720,000	$1,000,000
Extraction Pumps	4	ea	20,000	4,000	24,000	80,000	16,000	96,000
Pipeline	10,080	lf	50	58	108	504,000	584,640	1,088,640
Subtotal								$2,184,640
Treatment Facilities								
Start-up Filters	2	ea	$33,000	$5,000	$38,000	$66,000	$10,000	$76,000
GAC Units	10	pairs	160,000	1,600	161,600	1,600,000	16,000	1,616,000
Effluent Tank	1	ea	60,000	30,000	90,000	60,000	30,000	90,000
Backwash Tank	1	ea	27,000	8,000	35,000	27,000	8,000	35,000
Backwash Pump	1	ea	5,000	1,000	6,000	5,000	1,000	6,000
Chlorination System	1	ls	25,000	6,000	31,000	25,000	6,000	31,000
Building	480	sf	50	20	70	24,000	9,600	33,600
Structural	1	ls			80,000			80,000
Site Work & Yard Piping		ls			160,000			160,000
Site Electrical		ls			80,000			80,000
Subtotal								$2,207,600

Table 13-5 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 2: AQUEOUS-PHASE GAC WITH MUNICIPAL END USE

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST (Cont.)								
End Use								
Booster Pumps	4	ea	$15,000	$2,000	$17,000	$60,000	$8,000	$68,000
Subtotal								$68,000
G/W Monitoring Wells								
Wells	4800	lf	$50	$105	$155	$240,000	$504,000	$774,000
Subtotal								$774,000
TOTAL CONSTRUCTION COST								$5,204,240
Contractor OH & P		15%						$780,636
Engineering & Const. Management		15%						780,636
Administration		5%						260,212
Contingency		20%						1,040,848
TOTAL CAPITAL COST								$8,066,572

Table 13-5 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 2: AQUEOUS-PHASE GAC WITH MUNICIPAL END USE

Description	Utilities	Materials	Labor	Total
ANNUAL O&M COST				
Groundwater Extraction				
Extraction Wells	$238,270	$20,000	$16,000	$274,270
Pipeline	0	10,000	5,000	15,000
Subtotal				$289,270
Treatment Facilities				
GAC Units	$0	$550,000	$11,000	$561,000
Backwash Pumps	50	500	500	1,050
Chlorination System	650	6,200	7,200	14,050
Subtotal				$576,100
End Use				
Booster Pumps	$210,240	$16,000	$8,000	$234,240
Subtotal				$234,240
Groundwater Monitoring				
Monitoring Wells	0	$33,600	$35,200	$68,800
Subtotal				$68,800
TOTAL ANNUAL O&M COST				$1,168,410
PRESENT WORTH OF ANNUAL O&M COST				$17,961,326
TOTAL PRESENT WORTH				$26,027,898

Table 13-6

DESIGN CRITERIA
ALTERNATIVE 3

Item	Units	Quantity
GROUNDWATER EXTRACTION SYSTEM		
1. Extraction Wells		
Number	each	4
Capacity (each)	gpm	1,750
Total Capacity	gpm	7,000
Estimated Well Depth	ft	1,000
Approximate Depth to Groundwater	ft	150
Casing Diameter	inch	20
Approximate Pumping Head (each)	ft	200
Extraction Pump Rating (each)	hp	90
2. Raw Water Transmission System		
24-inch Diameter	lf	2,680
18-inch Diameter	lf	3,800
16-inch Diameter	lf.	3,600
TREATMENT SYSTEM		
1. Plant Capacity	gpm	7,000
	MGD	10.1
Influent Concentration		
Tetrachloroethylene (PCE)	$\mu g/\ell$	30
Trichloroethylene (TCE)	$\mu g/\ell$	10
cis-1,2-Dichloroethene (cis-1,2-DCE)	$\mu g/\ell$	10
Effluent Concentration		
Tetrachloroethylene (PCE)	$\mu g/\ell$	2.5
Trichloroethylene (TCE)	$\mu g/\ell$	2.5
cis-1,2-Dichloroethene (cis-1,2-DCE)	$\mu g/\ell$	3.0

Table 13-6 (Cont'd.)

DESIGN CRITERIA
ALTERNATIVE 3

	Item	Units	Quantity
2.	Treatment		
	Type: Air Stripping with Off-Gas Treatment		
	Number of Air Stripping Towers	each	3
	Operation	--	parallel
	Flow Per Unit	gpm	2,333
	Flow Per Unit (one unit off line)	gpm	3,500
	Diameter (each unit)	ft	10
	Packing Height (each unit)	ft	16
	Overall Height (each unit)	ft	28
	Air Flow (each tower)	cfm	7,800
	Air Flow (total)	cfm	23,400
	Air/Water Ratio	--	25:1
	Hydraulic Loading Rate (normal operation)	gpm/ft^2	29.7
	Hydraulic Loading Rate (one unit off line)	gpm/ft^2	44.6
	Number of Blowers	each	3
	Blower Motor (each)	hp	5
	Number of Air Heaters	each	3
	Air Heater Rating (each)	kW	40
	Number of GAC Units	each	3
	Carbon Weight (each GAC unit)	lb	12,500
	Carbon Weight (total)	lb	37,500
	Estimated Carbon Life (per unit)	days	228
	Estimated Annual Carbon Usage	lb	60,000
3.	Effluent Tank		
	Working Capacity	gal (1000)	175
	Size (Diameter x Height)	ft	44 x 16
	Seismic Construction	--	anchored
4.	Disinfection		
	Type: Gaseous Chlorine		
	Dosage Rate	mg/L	0.5 - 1.0
		lb/day	42 - 84
	Residual	mg/L	0.3 - 0.5
	Unit Size	lb/day	200
	Control	--	continuous
	Storage Cylinder Size	lb	2,000
	Number of Cylinders	each	4
	Feed Pump	each	1
	Feed Pump Rating	hp	1

Table 13-6 (Cont'd.)

DESIGN CRITERIA
ALTERNATIVE 3

Item	Units	Quantity
5. Start-up Filtration		
Type: Bag Filters		
Number of Units	each	2
Number of Bags (per unit)	each	46
Flow Per Unit	gpm	3,500
Flow Per Bag	gpm	150
6. pH Control		
Number of Units	each	1
Approximate Influent pH	--	7.1 - 7.4
Approximate Effluent pH	--	7
Feed Pump	each	1
Feed Pump Rating	hp	1
<u>END USE</u>		
1. Municipal System		
Pumps: Vertical		
Number	each	4
Total Pumping Rate	gpm	7,000
Pumping Rate (each)	gpm	1,750
Approximate Pumping Head (each)	ft	175
Pump Rating (each)	hp	80